

Original Paper

In China, What We Need is More Than Mathematics: A Literature Review of Numeracy

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Abstract

In China, the importance of quality mathematics education has never been called into a question, whereas numeracy as a general capability that is more than the mastery of mathematical knowledge and skills is seldom discussed in the literature about Chinese schools and education systems or considered in teaching practices, presenting an overall picture that numeracy development seems to be missing from Chinese education or considered as a tacit outcome automatically produced by the acquisition of mathematical knowledge. This issue may stem from the linguistic differences between English language and non-English language that render the interpretation of numeracy distorted and further evolve into a whole situation in China as a result of the longstanding debate on the essence of numeracy and the heavy emphasis laid on mathematics education rather than numeracy development as a whole. In this paper, the nature of numeracy is discussed by referring to a number of classic literature works, with special attention to clarifying the relationships between numeracy and mathematics that can be confused at a conceptual level.

Keywords

Numeracy, Mathematics, Education, Teaching and learning

1. Introduction

Chinese students begin learning mathematics from a rather early age, and when they are memorising the so-called multiplication table invented by Chinese mathematicians thousands of years ago as a must-have mathematical skill required in primary schooling, their peer groups in western countries are still working on simple mathematical operations like addition and subtraction using concrete methods with the assistance of hands-on tools and materials. In China, mathematics education cannot be better described than by calling it a pedagogical discourse that is “strongly shaped by consensual and differentiating rituals that buttressed a broader cultural respect for valuing esoteric forms of

mathematics” with students exposed to and involved in the acquisition of mathematical concepts and knowledge in teacher-centred settings (Norton & Zhang, 2013, p. 1). This highly knowledge-oriented learning and teaching pattern may explain the research findings that Chinese students normally outperform the counterparts of other countries as to the academic performance of mathematics (Di Paola, 2016; Drury, 2018; Fan, 2006; Kember, 2016; Mu, 2018; Wang & Lin, 2005; Zhang, 2017; Zhao, 2016; Zhao & Singh, 2011; Zhou & Xin, 2012). However, is mathematics expertise equal to numeracy proficiency? It seems so in China’s education system and for some Chinese educators who usually compare numeracy to mathematics or arithmetic from a narrow perspective (Cai, 2020; Cheng et al., 2010; Cheng, 2012; Huang et al., 2018; Zhang, 2018), while what concerns me most as an educator is that numeracy is far more than mathematics, and in Chinese context, this discrepancy and the nature of numeracy are rarely considered by policy makers, educators or school teachers, and thus, Chinese students are deprived of the chance to develop numeracy containing a range of skills and attributes that are far more than mathematical knowledge. This sort of absence may stem from the linguistic differences between English and Chinese, which is described by O’Donoghue (2002) as the fact that in certain non-English cultures, “there is no corresponding term in the languages” but mathematics or mathematical skills to generalise what numeracy implies (p. 47). Thus, what does indeed numeracy mean? Is numeracy identical with mathematics?

2. What is Numeracy?

2.1 A Longstanding Debate

The definition of numeracy varies. More than a half-century ago, numeracy was defined as the mirror image of literacy and the minimum grasp of disciplinary knowledge of mathematics and science that everyone should have so that they could be considered as educated (Crowther, 1959). Afterwards, in the 1960s, the understanding of numeracy shifted from the basic knowledge of numbers and its “function in other areas of life to the interpretation of data and the connections that allow us to understand the worlds of business, science and technology” (Kus, 2018, p. 59). Dozens of years later, more attention was paid to numeracy as a necessity skill for daily lives, with the most popular opinion being that numeracy is all about “possessing an at-homeness with numbers and an ability to use mathematical skills to cope confidently with the practical demands of everyday life” (Cockcroft, 1982, p. 11). The twenty-first century has witnessed the boom of numeracy interpretations and definitions. On the one hand, numeracy is still often simply interpreted as the “the ability to reason and to apply simple numerical concepts” (Attali & Bar-Hillel, 2020, p. 93; Decin, 2018, p. 68280; Knaus, 2015, p. 34; Mahendru & Mahindru, 2014, p. 11) or the ability to understand and work with numbers (Lister, 2013; McGarry et al., 2016; Mensah, 2016; Osafehinti, 2008; Oxford University Press, 2012; Parvanta et al., 2017; Rothman et al., 2009; Spithourakis & Riedel, 2018; Wallace et al., 2019). On the other hand, fortunately, more detailed definitions have been given with a far wider look. For example, Nygaard and Hughes-Hallett (2001; as cited in Diefenderfer et al., 2006) consider numeracy as quantitative literacy

and maintain that more than mathematical concepts, “quantitatively literate citizens (should) have a predisposition to look at the world through mathematical eyes...and to approach complex problems with confidence in the value of careful reasoning” (p. 41); while PISA defines numeracy as a sort of mathematical literacy that implies “the capacity to identify, to understand, and to engage in mathematics and to make well-founded judgements about the role that mathematics plays, as needed for” various aspects of everyday lives (OECD, 2000, p. 50). Since the concept of numeracy firstly appeared in public view, there has been a continuing debate and divergence of opinion about the nature of it.

2.2 An Australian View

Australia plays a leading role in the field of numeracy development and attaches great importance to it as a requisite general capability for their students and young citizens. At a conceptual level, the Australian Curriculum, Assessment and Reporting Authority [ACARA] (n.d.a) gives a remarkably systematic and comprehensive explanation of numeracy, regarding it as a set of “knowledge, skills, behaviours and dispositions that students need to use mathematics in a wide range of situations”, with which learners are able to become numerate and confidently and purposefully develop and utilise mathematical skill and knowledge both in academic studies of diverse areas and subjects and in daily lives (para. 1). In line with this, Perso (2006a), a distinguished Australian mathematics practitioner, summarises that numeracy is fundamentally about “what mathematics people know”, “how well people apply mathematics to practical situations” and “how well people draw on mathematics when dealing with everyday situations in which mathematics is embedded” (p. 20).

Here, confusion may occur with regard to mathematics, as it is a highly academic subject covering a vast repertoire of knowledge. In this case, what kind of mathematics or mathematical knowledge is sufficient for a person in order to be considered numerate? The ACARA (n.d.a, “Organising elements for Numeracy”) identifies six mathematical elements that are needed in the numeracy and learning continuum, including:

Estimating and calculating with whole numbers: Students apply skills in estimating and calculating with whole numbers to solve and model everyday problems in a wide range of authentic contexts using efficient mental, written and digital strategies...(and) identify situations where money is used and apply their knowledge of the value of money to purchasing, budgeting and justifying the use of money.

Recognising and using patterns and relationships: This element involves students identifying trends and describing and using a wide range of rules and relationships to continue and predict patterns.

Using fractions, decimals, percentages, ratios and rates: Students visualise, order and describe shapes and objects using their proportions and the relationships of percentages, ratios and rates to solve problems in authentic contexts.

Using spatial reasoning: Students visualise, identify and sort shapes and objects, describing their key features in the environment...and use symmetry, shapes and angles to solve problems in authentic contexts and interpret maps and diagrams, using scales, legends and directional language to identify and describe routes and locations.

Interpreting statistical information: Students solve problems in authentic contexts that involve collecting, recording, displaying, comparing and evaluating the effectiveness of data displays of various types...and use appropriate language and numerical representations when explaining the outcomes of chance events.

Using Measurement: Students estimate, measure, compare and calculate using metric units when solving problems in authentic contexts...and read clocks and convert between time systems, identify and sequence dates and events using a calendar and use timetables for a variety of purposes.

These elements well summarise the basic mathematical knowledge and skills that one needs to possess in order to be numerate. Undoubtedly, they do not represent all the learning areas of mathematics involved in schooling but are rather necessary for numeracy development and basically cover all the mathematical thinking skills that could be used to effectively deal with various numeracy situations in daily lives.

2.3 Numeracy Model for the Twenty-first Century

However, Goos (2007; as cited in Goos et al., 2012) argues that the description of numeracy should keep abreast of the times and take into account the changing nature of knowledge, work and technology, and even though the widely accepted definitions of numeracy have well summarised the features of numeracy for student educational achievement and curriculum design, very little instruction related to the plan of numeracy development at school is given to teachers and educators (Goos et al., 2014) who play an undeniably huge role in their student numeracy development (Bennison, 2014; Perso, 2006b). In this regard, a numeracy model for the twenty-first century was formulated to depict numeracy in the new era.

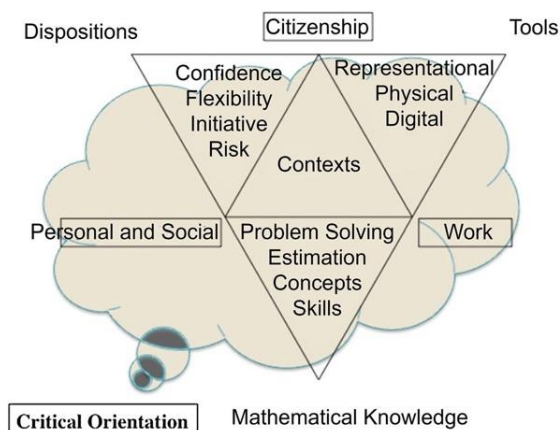


Figure 1. Merrilyn Goos Model for Numeracy in the 21st Century (Goos et al., 2012, p. 4)

As shown in Figure 1, this numeracy model centres around meaningful and authentic contexts, which specifically refers to the ability of applying mathematics knowledge in various situations, whether that being in schools and multi-disciplinary learning or out of school settings and in daily lives, and in general, the applied mathematical knowledge includes “mathematical concepts and skills, problem-solving strategies, and estimation capacities” (Goos et al., 2014, p. 84). Mathematical thinking here can be enabled, shaped and mediated by the use of tools, and they do not only include traditional physical and representational tools like models and maps, but also digital tools, such as Internet and modern electronic devices. To be numerate and effectively apply mathematics and tools into contexts, positive dispositions—the “confidence and willingness to engage with tasks and apply mathematical knowledge flexibly and adaptively”—and a critical orientation that represents the “use of mathematical information to make decisions and judgments, add support to arguments, and challenge an argument or position” are both necessary (Goos et al., 2014, p. 84), and here, the application of mathematics does not remain at the status of simple and mere application for purposes. The combination of all of these makes a person numerate and equips them as active and learned citizens with the numeracy skills for efficient participation in future workplace, productive contributions to society and personal achievement and development.

3. Numeracy and Mathematics

3.1 Mathematics Education in China

Admittedly, numeracy is interwoven with mathematics, and as discussed above, the real numeracy contains a range of developmental areas. It is just the complexity of such that may lead to conceptual confusion or misunderstanding amongst teachers and educators, which meanwhile worries me a lot with regard to the numeracy development in China and should call urgent attention from Chinese teachers and educators. In Chinese, numeracy is normally translated into the skill or knowledge related to mathematics, and indeed, these two differing terms “are often used interchangeably in schooling and in general usage” to depict the same numeracy picture (Perso, 2011, p. 32). This interpretation under Chinese context is not only a result of the aforementioned linguistic differences between English language and non-English language that make the translation of numeracy distorted but also because of the great importance attached to mathematics as a compulsory disciplinary subject by Chinese society. Since the 1950s, significant reforms of the mathematics education in China have been witnessed, and according to the Mathematics Curriculum Standards of Compulsory Education, mathematics education is to fulfil student needs in a range of life situations with the assistance of teachers, information communications technology and pragmatic and challenging learning materials (Guo et al., 2018), the major features of which in real classroom application are that academic mathematical knowledge is viewed as the primary pedagogical focus and that student proficiency of such is highly valued (Wang et al., 2017; Xie, 2009).

Regarding the purpose of Chinese mathematics education itself, I cannot find any problems with it, and instead, I would like to rate it as a prime guideline that is comprehensive and pragmatic and challenges the common stereotype towards the Chinese education system that is always described as rigid and unpractical. Even in a global setting, China's view on the objective of mathematics education keeps up with the current of time and basically corresponds to the popular thought that mathematics acquisition is for the purposes of practical application (Brez & Allen, 2016; Giardini, 2016; Gravemeijer et al., 2017; Österman & Bråting, 2019; Siller, 2011; Sparrow, 2008; Sullivan, 2011; Sutton & Krueger, 2002; Wong et al., 2012). However, the real teaching practices in classroom seem to be off the trail of the principal purpose of mathematics education and actually do not overstep the boundary of the so-called "powerful knowledge" that simply stresses the deep conceptual understanding of mathematics (Golding, 2018). Meanwhile, it is interesting to note that certain features of China's view on mathematics education overlap with the ones of numeracy, including meaningful application in contexts and use of tools. I cannot be too critical of such, but if this commonness and the emphasis on 'powerful knowledge' just allow for the replacement of numeracy by mathematics, the scope of the former will be evidently narrowed down with Chinese educators and teachers easily leaning into the failure that without an explicit conceptual understanding of numeracy, they are unable to address the demands of developing numerate students and young people (Perso, 2006a). Thus, in what follows, I will clarify the relationships between numeracy and mathematics and visualise them using two-set Venn diagrams.

3.2 Relationships of Mathematics and Numeracy

According to the above discussion, it can be assumed with little doubt that numeracy and mathematics are interconnected with each other, and they two are not in a discrete relationship as shown in Figure 2. Also, they are not the synonyms for each other, and numeracy generally covers more aspects that are not solely about mathematics. However, is there a situation shown in Figure 3 that numeracy is a part of mathematics? The answer is positive, whereas we need to be particularly careful with the way of how numeracy is linguistically described and narrowed down in scope, which means that we should use the notion of basic numeracy here instead of numeracy as a holistic and broad concept.

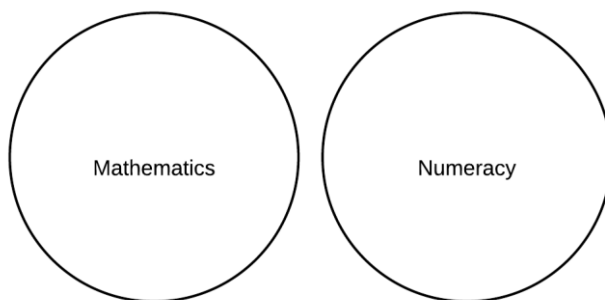


Figure 2. Mathematics and Numeracy are Discrete

Actually, basic numeracy appears to be a non-mainstream concept, and it might be originally defined by Girling (1977) who considers it as the capability to sensibly use a four-function calculator to complete basic mathematical operations. Currently, it usually refers to the ability to count and calculate numbers with the use of simple operations and the knowledge of arithmetic (Buckley, 2007; Lee et al., 2019; Magdaş & Răduţ-Taciu, 2014; O'Toole, 2015; Reyna et al., 2009; Ugorji et al., 2018) or identify and understand numbers and data without the manipulation of fingers (Dreeben, 2010; FitzSimons & Coben, 2009; Mazanec & Panke, 2016). These views are actually of little difference from the aforementioned definition that 'numeracy' is about the knowledge of numbers, and in this sense, mathematical proficiency could be more than basic numeracy (Lott, 2007).

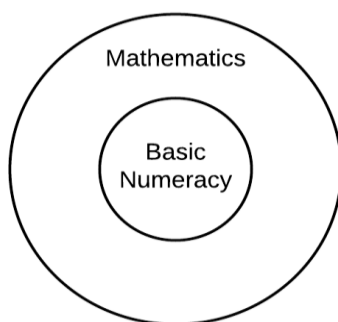


Figure 3. Basic Numeracy is the Subset of Mathematics

However, a problem with the notion of basic numeracy is that teachers and educators may easily fall into the trap of equalling basic numeracy to the broader concept of numeracy with further misunderstanding or assumption that mathematics education is the same as numeracy development, as shown in Figure 4 that depicts numeracy and mathematics as the same picture. This relationship is generalised by Withnall (1994) as the homogenisation of numeracy and formal education with the belief that specific standard teaching methods of mathematics would automatically generate numeracy achievement without taking into account the diverse contexts in which mathematics can be utilised, and mathematics teachers, in this regard, play the role as the gatekeepers and imparters of mathematical knowledge, the proficiency of which determines if a student is well educated and numerate.

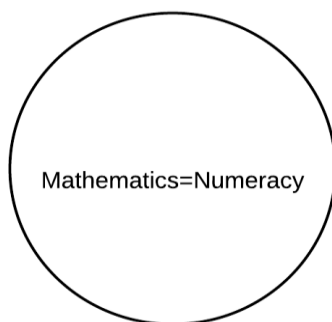


Figure 4. Numeracy is Mathematics

Nevertheless, this homogenisation cannot stand up to detailed criticism when the following questions are posed and examined: “Is mathematics education the only way of developing numeracy?”, “Is numeracy achievement the automatic result of mathematics learning?”, “How does this automatic transition happen?”, and “Can mathematical proficiency reliably reflect the education and numeracy level of a person?”. Indeed, as mentioned before, numeracy and mathematics are not the synonyms for each other, and the former, a broader term that is more than arithmetic or mathematics (Kissane, 2012) that could be conceptual or context-free (Orrill, 2001), contains both daily practices and educational aspects connected to mathematics (Goos et al., 2015) that plays “a central role in the development of numeracy in a manner that is more explicit and foregrounded than is the case in other learning areas” (ACARA, n.d.b, p. 2), just as illustrated in Figure 5 in which mathematics is at the core of numeracy that has a wider scope.

Yet, in comparison with the relationships that mathematics is more than basic numeracy or that mathematics is identical to numeracy, Figure 5 obviously presents a more comprehensive and appropriate connection of them. The reasonability of such lies both in the numeracy model for the twenty-first century—that highlights the multi-aspects of numeracy development covering authentic contexts, mathematical knowledge, application of tools, positive dispositions and a critical orientation—and in the systematic definitions of numeracy quoted in this text whose shared feature is that numeracy is no longer limited within the scope of mathematics.

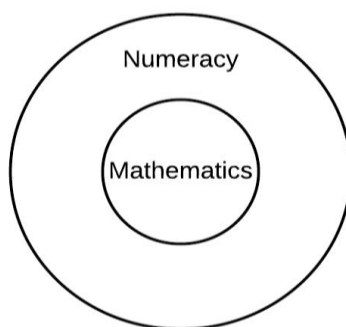


Figure 5. Mathematics is the Subset/at the Core of Numeracy

Although the “subset-superset” relationship of mathematics and numeracy makes sense, it is still not precise enough, and one may argue that mathematical thinking of all kinds does not have to be a part of numeracy, especially given that Chinese students need to acquire profound mathematical knowledge that they may never use out of school settings, such as functions, derivatives and calculus. Likewise, possible misunderstanding may occur by categorising mathematics as a part of numeracy and the core of numeracy development in the manner that mathematics as a disciplinary subject is overly emphasised without considering the possibility of developing numeracy in other learning areas and situations, which to some degree, falls back to the superficial view that numeracy and mathematics are one and the same.

In this case, Figure 6 provides a more proper representation that numeracy and mathematics overlap but are still distinguishing with certain developmental and learning areas unique to each other. This makes sense in the way that there are certain mathematical skills, such as algebra, that may be unnecessary to develop numerate abilities and that in order to be numerate, certain aspects, such as disposition and confidence, could not be simply gained from mathematical learning (Perso, 2006a). Otherwise stated, this perspective not only acknowledges the role mathematics plays in numeracy development without neglecting the nature of numeracy that is not restricted to mathematics application, but also fully takes into consideration the various possibilities that numeracy as a general capability can be acquired and promoted in multi-disciplinary learning and various situations of daily lives.

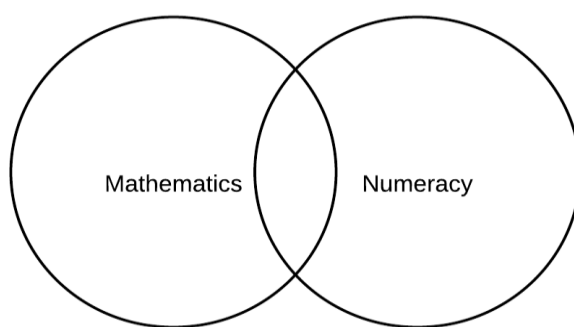


Figure 6. Mathematics and Numeracy Overlap but with Distinguishing Areas

4. Conclusion and Implication

Numeracy is a complicated concept in education. Traditionally and simply, it is defined as mathematical ability and knowledge, and this definition is still widely accepted both internationally and under the local context of China where the significance of mathematics in schooling has never been called into a question. This sort of interpretation somehow narrows down the scope of numeracy and is problematic in the manner that it does not go beyond the boundary of mathematical education and thus deprives students of the chance to develop numeracy as a broad and holistic capability that signifies the application of mathematical knowledge and assisting tools into a diversity of contexts with positive dispositions and a critical orientation.

Mathematics is interwoven with numeracy, and their relationship varies. It can be said that mathematics is the core of numeracy development, numeracy covers more aspects that include but not limited to mathematics, or numeracy and mathematics overlap with distinguishing skills that are unique to each of them. However, whichever way the relationship is going, an essential point that needs to be conceptually clarified is that though mathematics plays an important role in numeracy development, it obviously does not represent the whole picture of numeracy as a general capability that asks for a diversity of skills and attributes.

For teachers and educators based in China, they do need to obtain a deep conceptual insight about the nature of numeracy, only with which could they efficiently cope with student numeracy needs.

Although mathematics as a school subject is of paramount importance, what we need at a macro level is to develop active and numerate citizens who are well prepared for and able to flexibly and proficiently tackle everyday situations that involve the use of mathematics, rather than to stiffly train every student into expert mathematician or the so-called “test machine” with an extensive and full repertoire of “dead” knowledge. Despite of a correct conceptual understanding, a whole-discipline approach should be adopted as well by teachers of diverse subjects, the practicability of which still originates in the nature of numeracy: although mathematics functions as an integrated part of numeracy development, the other learning areas and subjects can also provide students with the chance to employ and practice mathematical thinking and numeracy skills, making the development of numeracy not the mere responsibility that mathematics teachers should shoulder.

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